Spring 2018

Recognizing the Beauty and Science of Diversity: A Tale of Orchidaceae

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EASTERN KENTUCKY UNIVERSITY

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Honors Thesis
Submitted
in Partial Fulfillment
of the
Requirements of HON 420
Spring 2018

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Abstract

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This honors thesis is a study of the diversity of the *Orchidaceae* family and the use of science and art to describe that diversity. The scientific topics about orchid diversity that are discussed are morphology, pollinator relationships, and the biogeographical range of the orchid family. These topics helped narrow down the species that were used in the artistic side of this thesis. The artistic aspect of this thesis includes four pieces of artwork that illustrate the beauty of the *Orchidaceae* family by showcasing specific species and using different mediums to capture the family in all its beauty. The four pieces include *A Moth and an Orchid* which is a continuous line drawing, *Bauer's Bee* which is a colored pencil drawing, *Orchids of Kentucky* which is a mixed media work that is a glass painting, and *Family Diversity* which is a collection of watercolor paintings. This thesis was inspired by both scientists and artists in hopes of giving a new perspective on the science and art of diversity.

Keywords and phrases: Orchidaceae, Orchids, Biogeography, Art, Science, Painting, Pollinator Relationship, Morphology, Thesis, and Honors Thesis

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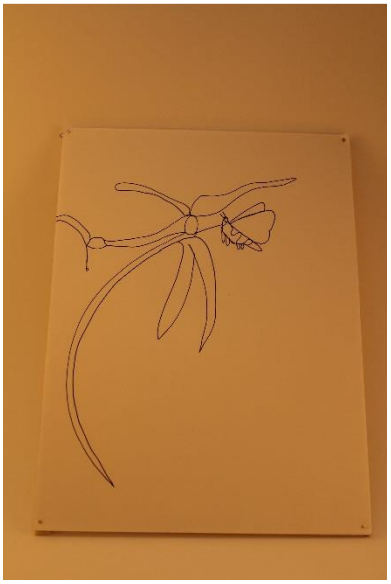

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Acknowledgments

I would like to thank several people for helping with this project. First, I would like to thank my mother and father for always telling me to give it my all when it comes to school. I wouldn't be the student I am today without them. I would like to thank my thesis mentor Melissa Vandenberg for making me pay attention to detail where I needed to and having patience with me. I would like to thank Kaity Ralston for creating my advertisement for my art exhibition and being a creative mind to bounce ideas off of. I would like to thank my fiancé Mason Reeves for encouraging me along the way and telling me not to quit. I would like to thank the administration team at the Noel Studio for Academic Creativity including: Rusty Carpenter, Trenia Napier, Clint Stivers and Tori Bowman for helping me through every step of the process and making the Studio home to Honors students like me. I would also like to thank the Honors Office for all that they have done for me the past four years. I would like to thank all of my friends for helping with brainstorming idea, putting together my exhibition, being a support in times of need and anything else you could possible imagine. My friends include Emily Adkins, Darby Campbell, Amanda Bowman, Rachel Latchut, Kennedy Morin, Abigail Byrd, Adrian Bryant, Erick Collings, Mari Garrison and Calvin Andries. To those who have helped me, thank you from the bottom of my heart.

Introduction

I have fallen in love with botany. Botany is the study of plants, including physical structure, genetics, ecology, classification, and their economic importance. The beauty and science behind plants is the core concept throughout this thesis project; to express science in a new light, specifically with art. Utilizing the *Orchidaceae* diversity as motivation for my thesis research, not only helps others understand science, but it also provides insight into who I am as a student and person.

The overall project focuses on certain areas that are important to the diversity of the *Orchidaceae* family; these areas include color, shape, and their individual pollinators. Looking at the *Orchidaceae* family, there are over 25,000 species that divide into five subfamilies (Gravendeel et al. 2004). The high number of species within the family *Orchidaceae*, makes it one of the most diverse families of angiosperms. I concentrated on this family because of the large number of species, aesthetic appeal, and the biogeographical range of the family.

At the heart of this research project is the diversity of the family and what makes orchids unique and distinctive from one another. Diversity is defined as the similarities and differences between things, in this case orchids. I focused on four individual works of art with the following themes, *A Moth and an Orchid* which depicts the unique relationship of orchids and their pollinators, *Bauer's Bee* which illustrates how orchids have been portrayed in the past, *Orchids of Kentucky* which investigates orchids that are native to Kentucky, and finally *Family Diversity* which explores color and shape diversity.

For my senior honors thesis, I combined my love for botany and my passion for art. I researched the diversity of the *Orchidaceae* family and use different art techniques and mediums to showcase the beauty of the family. Art can encourage an audience to explore science more deeply, and in this case the unique nature of orchids. The use of the visual art helps shed a new light on the science by looking at an otherwise challenging topic from a different perspective. This different perspective makes science more assessible to through art to people who would otherwise avoid science and it gives them an avenue to understand the information.

As a biology major, I encounter many different courses related to wildlife, and the course that hit home for me the most was my BIO 335 (Plant Systematics) class my junior year. This class opened my eyes and allowed me to look past the basics that are taught about botany in other classes. We looked deeper into the inner workings of the plant's structure and how the plants are classified within families. This led me to the family *Orchidaceae* – the family that orchids are classified into. I have always had a

fascination with orchids because of the unique aesthetic and the almost alien appearance that draws the eye of so many people.

Morphology

One of the reasons that I chose to focus on orchids is because of how they look. Morphology is defined in the field of biology as the study of living organisms in relation to their structures. For a long period of time most organisms were arranged in the tree of life based on morphology, but now they are relying on new genetic testing technology to build a tree of life that more closely reflects the relationships between the organisms. In the case of orchids, their phylogeny was reevaluated in 2015 by looking directly at the DNA.

Freudstein and Chase (2015), conducted a study to analyze the phylogenetic relationships of the Epidendroideae subfamily because it is the largest of the five subfamilies within the *Orchidaceae* family. This subfamily contains approximately 76 percent of the family species, and to be able to classify this subfamily properly through DNA analysis, would allow for the patterns of diversification to be understood and to comprehend the change in morphological characteristics within the *Orchidaceae* family.

Pollinator Relationships

A key component to understanding any plant, particularly flowers also known as inflorescences, is what type of organism is pollinating them. Without pollination, plant species that need sexual reproduction to occur to produce seeds would start to dwindle in population size. Orchids require pollinators for the pollination of their flowers. Orchids produce their pollen as small balls called pollinia, and each of these balls can contain millions of compacted grains that can be used to pollinate other orchids of the same

species. The pollinator for each orchid can change the morphology of the plant and make the orchid more competitive for its pollinator. This type of behavior can be seen when an orchid uses sexual deception in which the inflorescence mimics the signals of female insects so they can attract the male insect to pollinate. This can lead to pseudocopulation, which is where the orchid elicits copulatory behavior in the male insects. (Micheneau et al. 2009).

With approximately 25,000 different species of orchid in the world, there are vast differences in what type of pollinator each species has and how they attract them. According to Garcia-Cruz et al. (2009), the way orchids attract their pollinator plays a key role in the genetic structure and identity of the orchid and it is responsible for the differences between individual species. The genus that Garcia-Cruz et al. (2009) focused on was the *Govenia* genus, in which they selected six species to compare orchid genetics to a common ancestor. Each of the orchids have a similar pollinator in that the bumblebees are the primary mechanism of breeding for the *Govenia* genus. Although the bumblebees are the pollinator for these species the overall look of the six species is different.

There are three main phylogenetic groups within the genus and all look like one another but have subtle differences. The Purpusii group is characterized by small plants and small inflorescences, the Capitata group is characterized by medium sized plants with its inflorescences near the top of the stem, and finally the Superba group is distinguished by larger plants and larger inflorescences. Each species in this genus share the same type of pollinator and still have a high genetic diversity within the genus. Species that live within the same geographic region compete for the same type of pollinator. This is

competition can be seen by the number of inflorescence that each species has and the greater the number of inflorescences the greater the reward for the pollinator. The *Govenia* genus is unique in that it can also be pollinated by the wind. Each pollination strategy can be different for each orchid, and even if they have the same pollinator they can look extremely different. (Garcia-Cruz et al. 2009)

Biogeography

The *Orchidaceae* family is one of the largest families of angiosperms. This family also grows in habitats that span around the world. According to Guo et al. (2012), two-thirds of the family grow within the tropical regions in herbaceous habitats with high species diversity in these areas. *Orchidaceae* has species that are found almost everywhere except in Antarctica and the Arctic. The geographic diversity of this species illustrates the overall diversity by showing how it can grow in most places, but orchids are also limited in where they can grow in those places too.

Orchids are limited in their growth because of a symbiotic relationship that orchids have with mycorrhizal fungi. This relationship limits the grow because without the fungus present it can lead to a lower population size and reduce the occupancy of habitable areas (Davis et al. 2015). In addition to symbiotic relationships, the distribution of the pollinator can also limit the range of the orchid species. If the specific pollinator is not found in that area then the likelihood of the orchid that it pollinates being in that area is slim. Another factor that effects orchid populations is the elevation at which it is growing. Orchids that grow at higher elevation tend to be epiphytic, meaning that they grow anchored to other plants and that orchids that are terrestrial, which means growing in soil, tend to grow at lower elevations (Wagner 2012). The niche that is filled in each of

these areas by the orchids allows for it to grow only in these areas because of the resources available to the orchid and the other species that it competes with for those resources.

Introduction of the Art

On the surface the relationship between science and art is non-existent. People tend to ignore the connection and take the idea of art and science and group the fields separately because of how different they look on the surface. This assumption greatly masks the relationship of science and art, and the need for these two fields to co-exist seamlessly. Once the relationship is examined at a deeper level there is an obvious connection that is unmistakable. Botanists use art to illustrate the plants encountered in the wild, and during the 17th and 18th centuries their artistic ability was the only way for plant species to be observed by others. The drawing skills of botanists had to be average enough to depict the organism in all its beauty and be able to describe the species with the proper terminology. The invention of photography in the early 19th century and the development of it since has caused the need for botanists to no longer rely on their ability to draw the specimen because they can simply take a picture of it. The reliance on photography and technology have distanced the field of art and the field of science to their current standing today, which is completely separate.

The inspirations that led me to this creative thesis project include a variety of scientists within the field of botany and also those that have illustrated nature, but have no direct ties to the field of botany. The scientists that inspired my project include Charles Linnaeus and Charles Darwin. Charles Linnaeus is known as the father of modern taxonomy because he was the one who formalized the nomenclature system that

is used today to classify species. Linnaeus was also a botanist who struggled to draw the plants that he found and relied heavily on the terminology to describe his plants. (Reeds 2004) The other scientist that was an inspiration was Charles Darwin. Darwin is best known for his contribution to evolutionary biology. Darwin could make educated guesses on the pollinator by understanding the morphology of the plant and thinking about the structures that the pollinator would need to pollinator the flower. Specifically, Darwin looked at the length of the nectary on the orchid and from observations of moths knew that the pollinia would stick to the very end of the proboscis. (Arditti et al. 2012). With the observations from both the structure of the plant and the behavior of the moth Darwin predicted the pollinator relationship between the moth and the orchid.

I wanted the more historical experience of how the architects in the field of botany documented various plant species. This meant that I needed to work with mediums that were readily used in the illustration process, which included watercolor and ink. Four pieces were created using a variety of mediums both traditional to what botanists would use and more creative mediums that I had not worked with before. I used watercolor to create six paintings with small amounts of ink. I used colored pencils to create a drawing of an orchid. I included a piece that was solely ink to and my final piece included was mixed media of glass bottles and acrylic paint. I did use ink as either the sole medium or as an artistic addition used to define the edges of my work a little bit better. I also wanted to experiment with unique kinds of media and mix them together to produce eye catching art. This involved using glass and acrylic paint to display the orchid species chosen for the *Orchids of Kentucky* piece. Each piece was created using certain materials that make it unique but are also based in scientific descriptions of the species themselves.

A Moth and an Orchid

This piece centers on two organisms that have a pollination relationship that has co-evolved over time. The orchid species in this piece is *Angraecum sesquipedale* which is also known as Darwin's orchid, and the moth species is *Xanthopan morganii praedicta* which is also known as Morgan's sphinx moth. This relationship was predicted by Charles Darwin in 1862, well before the relationship was proven. Darwin's ability to recognize the shapes of the orchid helped him predict what the pollinator for the orchid would look like in addition to looking at the behavior of the pollinator.

The artwork was created to show the relationship of the two organisms and how without their connection to one another neither would survive on their own. The continuous line in this piece is used to represent the fragile connection between *A. sesquipedale* and *X. morganii praedicta* and how the nature of this relationship could easily be damaged by the changing environment as easily as a line can be erased.

To show the simple nature of this relationship I wanted to use a continuous line drawing, also referred to as a contour line drawing, a technique which appears to be simple on the surface but, is a complex and difficult process to complete. A continuous line drawing is a drawing that is an unbroken line from beginning to end. This mirrors the pollinator relationship by how it looks simple on the surface but is a complex relationship where both species have evolved new traits to continue this relationship. The ink pen that I used had to stay in contact with the paper for the entire length of the drawing. I have used this technique before, but not with any symbolism behind it.

Bauer's Bee

Bauer's Bee centers on one organism that has graced the covers of many orchid books and been a fascination to others because of the way that it looks. *Ophrys apifera* is an orchid that looks like a laughing bee and is commonly named the bee orchid because of its appearance. The name of the work is a tribute to an individual who inspired me with different techniques and ways to draw orchids. Franz Bauer (1758 – 1840) was a botanical artist who was a resident at the Kew Royal Botanical Gardens and created detailed paintings and drawings of flowers, particularly after dissections and usually from a microscopic point of view. (Stewart and Stearn 1993).

This species was of interest to me personally because when it is looked at directly it looks like a bee that is laughing. I decided to use colored pencils to illustrate this orchid because it would offer a soft color image of it and it would be using another medium that I was fairly new at using. Colored pencils are wonderful tools in that the amount of pigment that is transferred to the surface that you are working on it dependent upon the amount of pressure that is applied to it. This drawing also serves as a representation of how plants have been portrayed by botanical art over the years. It also shows some of the methods that illustrators and botanists alike would use to capture the image of a plant so others that may never have a chance to see them in real life can still experience their beauty.

Orchids of Kentucky

Orchids of Kentucky revolves around seven orchids that are native to Kentucky. The seven species that were chosen were *Calopogon tuberosus, Cleistesiopsis divaricata, Cypripedium acaule, Cypripedium kentuckiense, Cypripedium parviflorum, Isotria*

verticillata, and *Platanthera psycodes.* The purpose of this glass painting is to show that there are orchids that grow around where I live and that they do not look like the orchids that we are used to seeing in pictures and magazines. Not only did I want one of the pieces to focus on Kentucky, but I also wanted the materials to be Kentucky made materials.

The media used for this mixed media artwork were glass bourbon bottles and acrylic paint. I chose bourbon bottles because of how Kentucky is known for the bourbon that it produces. I also collected a variety of different types of bourbon bottles to show the diversity of the bourbon but also the diversity of the orchids that are native to Kentucky. There are four types of bourbon bottles used and each one represents a subfamily within *Orchidaceae*. Maker's Mark bottles represent the Vanilloideae subfamily, Woodford Reserve bottles represent the Cypripedioideae subfamily, Four Roses bottles represent the Orchidoideae subfamily and the Wild Turkey Bourbon bottles represent the Epidendroideae subfamily.

The bottles for each subfamily were chosen based off the size and scale of the flower that I was going to be painting on the glass. I did this to make sure that the species would fit on the bottle and that there would be enough space to show detail on the individual species. I chose acrylic paint because the orchids would look solid on the glass because of the pigment load of the paint. To apply the acrylic to the bottles I had to coat the bottles in Modge Podge to create a rough enough surface for the paint to adhere to on the bottle. The bottles were overall the most time-consuming piece because if I messed up one of the bottles I would have to go back through the process of removing the labels, cleaning the bottles, applying the Modge Podge, and painting the orchid on the bottle.

Family Diversity

This piece centers on the diversity of the *Orchidaceae* family as a whole, in both color and shape. The species that are represented in this piece are *Bulbophyllum fletcherianum, Caleana major, Dracula simia, Psychopsis papilio, Thelymitra variegata,* and *Zygopetalum maculatum.* The idea of this piece is to stand opposite of the *Orchids of Kentucky* piece in that I am now looking at the diversity of the *Orchidaceae* family and noticing the biogeographic range of this family. The species in this piece come from Australia, South America and the Pacific Islands.

For this piece I decided to use watercolor because it was a new medium that I did not really have any experience with. This medium is much more forgiving when working with it because if the color you are using is too dark then you can lighten it with water to wash out some of the pigment. Another crucial part of this piece is that all the components, individual orchid watercolor paintings, are attached to a wooden trellis. I chose to use a trellis to put the components on because of the idea of what a trellis is used for in a garden. In gardens a trellis is usually used to grow viney plants on so they can climb. I had a similar spatial reasoning behind the use of a trellis to show that the orchids that are being displayed have connections because they are in the same family, rather than being attached together by vines.

The overall look of the components is bright with varying colors ranging from red and green to purple and blue. I wanted to show the differences in the color of the orchids to help the audience realize how startling that these orchids look in relation to other type of flowers. The components use bright colors but the texture of the components is soft and muted because of the watercolors used.

Future Directions

The process of completing my thesis has been an exhilarating trip. I have learned to look at things from a scientific viewpoint with researching the relationships of the orchids to one another and to the environment. I now approach each situation that I encounter with an open mind but also to be mindful of the details of what I am looking at. I hope that I will be able to continue drawing and painting different species of plants that I come across in my future profession and if not keep practicing and become a better artist.

The biggest takeaways have been that I will only get better at something if I practice and work on it. I gained confidence in the artwork that I produce, in various media, and to have the courage to share with people what I can do. I believe that my artwork will inspire others to look at both science and art in a new light or from the other's perspective to bridge this gap that is growing between art and science.

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